Characterization of Zooplankton Community and Size Composition in Relation to Hydrography and Circulation in the Sea of Japan

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LONG-TERM GOAL

Our ultimate scientific goal is to understand both the biological (e.g., population structure and dynamics and behavior) and physical (e.g., advection, mesoscale physical processes, turbulence) mechanisms that act in concert to produce the observed distributions of plankton in the ocean. Our approach has been to conduct a combination of field, lab, and modeling studies. Field studies define the temporal changes in the distributional patterns of population structure resulting from population growth, swimming behavior, and physical transport. Laboratory studies yield insights into vital rates and behavioral patterns. Modeling ties together the vital rate and behavioral information with the population structure and transport data to determine the mechanisms responsible for observed population distributions.

OBJECTIVES

1) To characterize the zooplankton community of the Japan Sea in terms of taxonomic composition and size structure.

2) To characterize the scales of variability in the zooplankton of the Japan Sea over distances from centimeters to hundreds of kilometers.

3) To determine the relationship between zooplankton taxa and their associated environmental variables over scales from centimeters to hundreds of kilometers. This information will provide insights into the origins of the different zooplankton taxa.

4) To consider the potential flux or exchange of zooplankton into and out of the Sea of Japan through the straits, so that the contribution of physical exchange to resident populations can be quantified.

APPROACH

Our objectives require the ability to obtain high resolution temporally and spatially coincident measurements of both biological and physical characteristics, which then permits description of the coupling between biological and physical distributions and of the distributions of zooplankton and associated variables over scales from centimeters to hundreds of kilometers. To achieve this, we utilize a combination of new technology (the Video Plankton Recorder) coupled with more standard techniques (shipboard acoustic Doppler current profiler, net sampling). We obtained high resolution

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measurements of the basin-scale distributions of zooplankton abundance and taxonomic and size composition in relation to the hydrography, currents, light, fluorescence, and beam attenuation in the upper water column (80 m) using the Video Plankton Recorder (VPR) in the southern Japan Sea during the summer. The VPR is essentially an underwater microscope which images plankton at two different magnifications. The instrument is mounted on a V-fin which is towed behind the ship, undulating between the surface and a selected depth. Video images and associated hydrographic and biological data are transmitted from the towed vehicle to the ship via fiber optic cable. In-focus images of plankton are extracted from the video and identified to taxa in real time. Plankton abundances and hydrography are plotted in real time. We collaborated substantially with Dr. Lynne Talley (SIO), who was chief scientist on the cruise and conducted basin-wide CTD measurements as part of the ONR Japan/East Sea DRI, and welcome collaboration with other US and international scientists involved in the project who would find our data instrumental to achieving their research goals. We also will collaborate with Dr. Charles Flagg (BNL) who is processing the ADCP data. The work will provide a better understanding of how boreal and tropical zooplankton communities maintain themselves in a dynamic physical environment.

WORK COMPLETED

We successfully surveyed the plankton communities and associated hydrography and circulation in the Japan/East Sea during June 17 - July 23, 1999 on Dr. Lynne Talley's cruise on the *R/V Roger Revelle.* During this survey, we towed the VPR at ~9 knots between all CTD stations along the transect lines (Fig. 1). The instrument sampled between near surface and 80 m for much of the survey with an inter-profile distance of ~7 kilometers. We sampled over a total distance of 3562 kilometers and collected and processed over 240 hours of video and associated data. We collected also pressure, temperature, conductivity, fluorescence, light transmission, and ambient light data as well as logging P-Code GPS position and time (UTC) and Knudsen Echo Sounder depth. Acoustic Doppler current profiler data also were collected and presently are being processed and entered into a database at Brookhaven National Laboratory by Dr. Charles Flagg. During the cruise, hydrographic and taxon specific plankton distribution data were displayed in real time. In addition to our primary sampling with the VPR, we conducted 15 plankton tows using a 1-m^2 (mouth area), 150 µm mesh ring net towed obliquely between the surface and 80 m. The plankton samples assisted us in identifying exotic taxa that were seen in the video images and will be analyzed in the laboratory for plankton taxonomic and size composition.

We processed over 90% of the video images collected utilizing the high magnification camera at sea. Since returning from the cruise, we completed processing of the last ~10% of the video tapes from the high magnification camera.

We observed larger copepods to the north of the subpolar front which were well documented with the low magnification camera (images not analyzed at sea). In order to obtain a complete description of the size and taxonomic composition of the JES plankton, we are analyzing video images from the low magnification camera that were collected along the N-S transect lines.

We presently are beginning detailed analysis of the biological-physical associations, the size composition of plankton, and the regional and/or water mass variations in the relative abundances of the different taxa.

RESULTS

Analysis of the water column temperature revealed that, although our survey region was confined to the southern portion of the JES, we did cross the Subpolar Front which extends across the JES and separates the warmer water to the south from colder water to the north (Fig. 1).

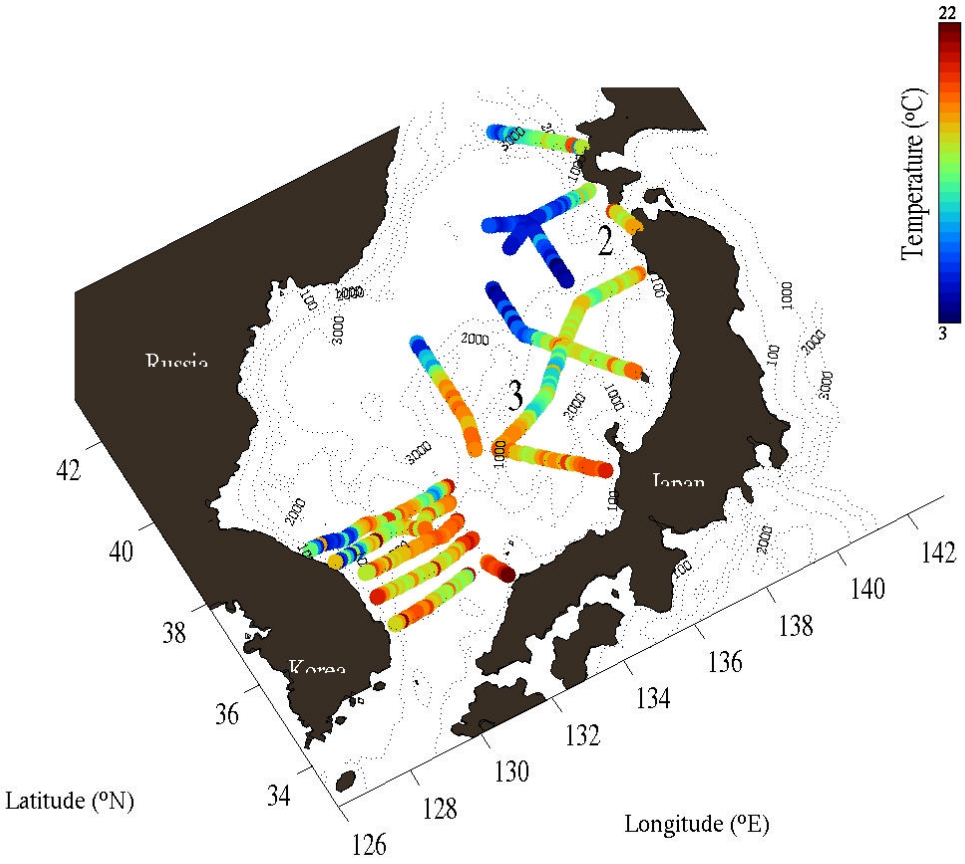

Figure 1. Locations of most VPR data and average water temperature in the upper in the upper water column. Data were averaged over the 0-80 m depth interval in along-track distance intervals of 10 kilometers. Additional data collected across Tsushima Strait (not shown). Numbers designate locations of transects presented in Figs. 2 and 3.

Real-time and preliminary plots of hydrographic (T, S, density) and biological (fluorescence, light transmission, unidentified copepods, diatom chains, and *Oithona*) showed strong vertical structure in plankton distributions that were associated with the physical environment (e.g., thermocline) (Figs. 3 and 4) and regional differences in the type and abundance of plankton. For example, few diatom rods were observed in the low salinity water in the upper 30 m of the Tsugaru Strait (Fig. 3). The distribution of calanoid copepods in the Yamato Basin appeared to be strongly associated with particular isotherms in the Yamato Basin (Fig. 4). Initial inspection of the net samples indicated strong variation in taxonomic composition between the different regions, which confirmed our preliminary observations from the VPR.

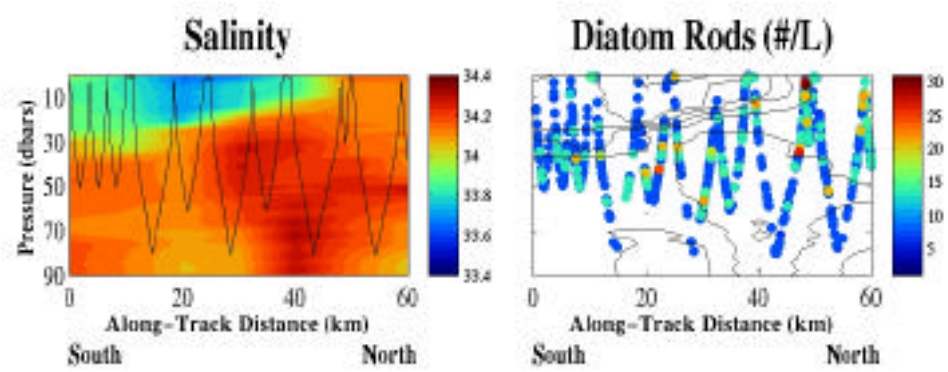

Figure 2. Distributions of salinity and rod diatoms from along a transect across Tsugaru Strait (Transect 2 in Fig. 1). The path of the instrument through the water is overlain on the contours of salinity (left panel). For diatom rod distributions, each dot indicates a distance-depth bin where diatom rods were observed; the color of each dot indicates the abundance of diatom rods at that location. Contours of salinity are overlain on diatom rod distributions.

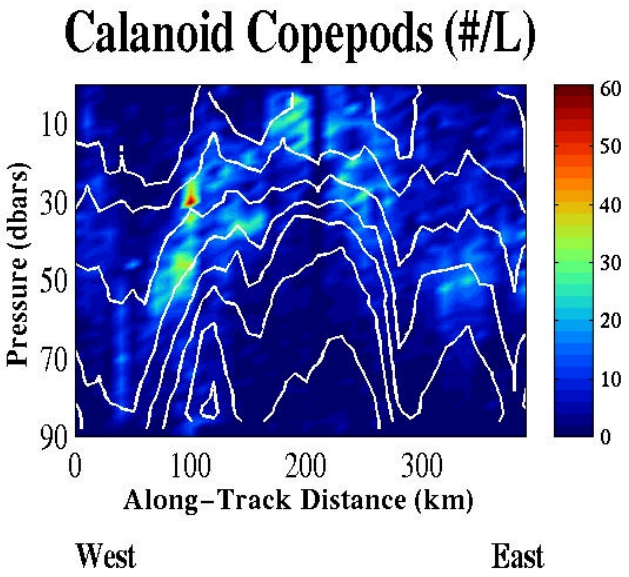

Figure 3. Distribution of unidentified calanoid copepods (color) along a SW-NE transect of the Yamato Basin (Transect 3 on Fig. 1). White lines indicate contours of temperature.

Future analyses will include: 1) describing the size distribution of taxa, 2) quantifying associations between different taxa and between taxa and environmental conditions, 3) examining the scale of variability of the distributions of zooplankton taxa, and 4) incorporating instantaneous velocity measurements collected with the shipboard acoustic Doppler current profiler to estimate of flux of plankton between different hydrographic regions and in and out of the JES. We have collected an exciting and unique data set that will yield valuable insight into the plankton ecology of the JES.

IMPACT/APPLICATION

The proposed study will shed light on the biological/physical interactions controlling zooplankton abundance and community structure in a semi-enclosed marginal sea. Using the data obtained, we can compare a largely closed temperate zooplankton community with one having similar taxonomic

composition but which is influenced more strongly by advective input (Gulf of Maine). We also will gain new insights into the impact of advective input of a tropical community into a boreal region. The mixture of the two communities and the potential establishment of a transitional community along the Subpolar Front will allow us to examine how the affinities of zooplankton communities change in response to advective transport over a broad range of scale and the roles of eddies and meanders in promoting exchange between different planktonic and hydrographic regimes. Such information will allow us to better understand how zooplankton communities maintain themselves in a dynamic physical environment.

TRANSITIONS

Our findings will allow better predictions of how zooplankton and large phytoplankton abundance patterns change as a function of hydrography and currents in the Japan Sea. More generally, the findings will provide a better understanding of how plankton and physical properties are distributed in relation to each other over a broad range of scales in the vicinity of a sharp biogeographic frontal region. This information then can be used to better understand variability in sound and light scattering properties of the ocean.

RELATED PROJECTS

1 – This work will be integrated with the Japan Sea DRI which involves many investigators in physical and optical oceanography.

2 – The Japan Sea findings will be compared with those from our GLOBEC Georges Bank VPR studies which are focusing on cross-frontal exchange of plankton.

PUBLICATIONS

Ashjian, C.J., C.S. Davis, S.M. Gallager, and P. Alatalo. Distribution of plankton, particles, and hydrographic features across Georges Bank described using the Video Plankton Recorder. *Deep-Sea Research II*, (In press).

Benfield, M.C., P.H. Wiebe, T.K. Stanton, C.S. Davis, S.M. Gallager, and C.H. Green. 1998. Estimating the spatial distribution of zooplankton biomass by combining Video Plankton Recorder and single-frequency acoustic data. *Deep Sea Res*. II, 45: 1175-1199.

Benfield, M.C., C.S. Davis, and S.M. Gallager. Estimating the in-situ orientation of *Calanus finmarchicus* on Georges Bank using the Video Plankton Recorder. *Plankton Biology and Ecology* (In press).

Davis, C.S., S.M. Gallager, X. Tang, L. Vincent and C.J. Ashjian. Real-time automatic identification of plankton. *Mar. Ecol. Prog. Ser* (In revision).

Sieracki, M., D. Gifford, S.M. Gallager, and C.S. Davis. 1998. Ecology of a *Chaetoceros socialis* Lauder patch on Georges Bank: Distribution, microbial associations, and grazing losses. *Oceanogr*.11: 30-35.